FORESTRY IN NORTH DAKOTA

With Recommendations for State and Federal Activities.

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General Discussion of Forest Possibilities of North Dakota.

The following report is supplemental to the Report by Raphael Zon under the title "The Forest Problems of North Dakota; Suggestions for Meeting Them", and under date of November 16, 1930. Both reports are the result, not of Forest Service ambition to inject itself into the affairs of North Dakota, but of a strongly-felt need on the part of many prominent cities of the State for greater activity in that region in growing trees upon the treeless plains, and upon the waste lands of the State. The feeling that something along this line should be done, and that it could only be done by the participation of the Federal Government, found expression in Senator Nye's Bill (Senate No. 4553) in the second session of the 71st Congress, to appropriate money for an investigation of the possibilities of forestry. While much investigation and experimenting should be done before it can be hoped that new forests will be established on any large scale, the present report is intended as a superficial discussion of the possibilities, based on the writer's experience and observation elsewhere, which includes a considerable familiarity with tree-planting in the plains region of Nebraska, Kansas and eastern Colorado, with sandhill planting in Nebraska, and with general conditions in the Bad Lands of South Dakota.

In presenting the complete set of photographs obtained during the examination of North Dakota conditions, the writer wishes to offer apology for the poor quality of a number of them which were necessarily taken under very unfavorable weather conditions.

Results of the Superficial Study

Based primarily on the physical conditions observed and the results of tree-planting by private individuals and institutions throughout the State, it appears that there are sanguine possibilities for timber growing in North Dakota on a scale sufficient not only to affect the future timber supply of the State but also, what is probably more important, to have an appreciable effect upon the climatic and aesthetic conditions of the most treeless plains. Only the planting of conifers in large bodies upon the sandhill areas should be considered primarily as a timber-producing undertaking; the more extensive and widespread planting which is needed even in the best of the farming regions should be taken up mainly for the influence which it may have upon living conditions and some ameliorating effect upon the drying power of winds; finally planting in the Bad-lands section of the State should be undertaken primarily for the control of erosion and for its influence upon the headwaters of the Missouri River.

These possibilities broadly stated suggest the following public actions:

1. Federal legislation to permit an exhaustive study of the possibilities of timber-growing in the sandhill region of

McHenry County by means of planting experiments over a number of years, gradually assuming larger and larger proportions as the success warrants it; and for such other investigations as may be necessary to forward the movement for more general tree planting, such as a study of the actual effects of windbreaks in relation to climatic conditions and crops. The necessary funds for such experimental work should logically be in the form of an addition to the appropriation for the Lake States Forest Experiment Station which will naturally be charged with the investigation of the matter.

2. Immediate amendment of the Executive Order of January 9, 1930, setting aside government lands in various parts of the State in aid of legislation then pending. It is not believed that Federal agencies can soon become interested in forest planting activities in the Turtle Mountain or Pembina Mountain regions, or even in the sandhills of Ransom and Richland Counties or the Lake-margin forests of the Devils Lake region. There then remains the definite outlined area in the sandhills of McHenry County in which all available Government land should be withdrawn(some not covered by the original Order) and the Bad-lands of western North Dakota in which, it is believed, no hardship would be imposed if all remaining Government land were withdrawn from entry untill the possibilities of erosion control by means of planting and engineering works shall have been demonstrated. This might well be a blanket withdrawal covering Billings County. The remaining public land in these two regions will probably give all the area needed for experiments.

3. While there is no urgent need for the purchase of land in McHenry County sandhills for such experimental planting as can be carried on in the next three or four years, it might be well to proclaim as soon as possible the boundaries of the proposed National Forest Unit in that region, and then to proceed with the acquisition of privately-owned land within these boundaries as the necessity develops and as advantageous opportunities are offered. To the latter end there is required an addition to the acquisition item of the Clark-McNary Law, amounting to probably $200,000 in the aggregate, a portion of which should be appropriated within the next year or so and made specifically applicable to North Dakota until expended.

4. The State of North Dakota, with or without the cooperation of the Federal Government, should consider the feasibility of establishing extended state forests in the form of narrow strips which will have the most widespread climatic effects. To this end the utilization of state-owned lands on section lines not needed for secondary roads is suggested, and its legality and acceptability to the rural population should be investigated.

5. The existing agencies which are growing tree-planting stock and which are establishing many successful small plantations on farms should be given every encouragement, and their well-organized efforts should be extended as far as possible, although the effort has been largely demonstrational up to the present time, and will probably never account for any very large acreage planted to trees.

The Physical Conditions

To the casual observer North Dakota is largely a treeless plain, and certainly in many parts of the state the landscape of endless wheat-fields or natural pastures might be greatly improved by the addition of a grove or belt of trees here and there. Yet, on close examination, it is found that the natural opportunities for the growth of trees are far more favorable than further south in the Great Plains region, under apparently similar conditions of soil and rainfall. This decidedly more frequent occurrence of natural forests farther north is generally ascribed - and it is believed this is the only logical explanation - to better conservation of the meager rainfall due to somewhat lower year-round temperatures, and consequent lower evaporation, with increase in latitude. Thus, with 15 inches of precipitation annually the fine clay soils of the Bad-lands of southwestern South Dakota are practically devoid even of herbaceous vegetation, except in occasional coves and pockets, while with the same precipitation in western North Dakota sufficient moisture penetrates and remains in the heavy shaly clays of the Bad-lands to support a moderately complete cover, including perennial shrubs. Here, with the slight improvement of moisture supply resulting from even small protected depressions, one finds such trees as western yellow pine and the still more common aspen, whereas in the southern region the more drought-resistant red cedar and green ash represent the maximum possibilities of the heavy soils.

Perhaps the most sensitive index to the contrasting conditions is the aspen, or "popple". Naturally a tree of the "northwoods" where it occurs with spruce and other conifers, the common aspen yet finds its way as far south as northwestern Iowa on the border-line between central hardwood forest and true prairie, and as far as north central Nebraska, on the very porous soil of the sandhills, with precipitation of 20 inches annually. In the latter location, however, it is rare, and barely subsists. In the north it reaches into the edge of the Red River valley, but eventually gives out upon encountering the heaviest gumbo soils, with precipitation of less than 25 inches in northern Minnesota, but more than this quantity toward the south. It again appears west of the Red River, in North Dakota, with 20 inches of precipitation, and "holds it own" pretty well across the State, with not more than 15 inches of precipitation at the western edge. This it does wherever there is the slightest improvement in the porosity of the soil above the general average, or the slightest opportunity for run-off or drifting snow to add to the local water supply, as in almost imperceptible depressions on the plains. Moreover, on such uplifts as the Pembina and Turtle Mountains (where there is better absorption and less run-off of rain water due to rocks in the soil, and irrespective of possibly greater precipitation resulting from elevation) and on the decidedly porous soils of the sandhills of McHenry and Richland Counties, the growth and stature of the aspen show that it is far from having reached its physical limits. These

are more nearly represented in the Bad-lands of western North Dakota where, with the minimum rainfall (15 inches) no conditions short of sub-irrigated river bottoms produce any impressive growth of aspen.

While the writer is not familiar with eastern Montana, it is the impression that the plains there, where for a considerable distance only 15 inches of rainfall are received, offer fewer opportunities for natural tree growth than do similar lands in North Dakota, and this is readily explained on the same basis as the less favorable conditions to the south, namely that proximity to the Rocky Mountains (without the effect of their elevation) means a greater loss of precious precipitation through evaporation. One has only to think of the extreme conditions represented by the Chinook wind to understand why a general tendency of this kind should exist.

This, then, forms the keynote of the present paper and is the basis for the optimism expressed as to the possibilities for forestry in North Dakota. The natural opportunities are far better than in Nebraska or farther south, where lines of equal precipitation would give the superficial impression that the moisture supply is as good. While North Dakota has an abundance of natural prairie and plain, on which tree growth probably never occurred, the barrier which must be overcome, by artificial means, to establish such growth in the north is a slight one, or at least not so imposing as that which has

been overcome on the similar prairies and plains to the south. If this be true of plains conditions, it is likewise true of sandhills north and south. The fact that forests of pine trees have been and are being established in the Nebraska sandhills, where aspen can maintain only a straggling foothold, is ample proof that moisture is sufficiently abundant in the Dakota sandhills to build an even more impressive forest, and possibly not merely a "cover" forest but one of real commercial value to the State.

There remain, then, the questions as to length of growing season and character of soil as affecting the relative value of forests in the plains region north and south. Regarding the general question of frost injury, winter-killing of trees and other temperature effects, it must be admitted that it may be necessary to employ different species for forest planting in the north, or at least to obtain seed from localities where it may be certain that a given species has been subjected to, and has succeeded in spite of, the rigorous conditions of the north. Specifically, one would not select seed of western yellow pine for planting in North Dakota, from the same forests which have given the best seed supply for the conditions of Nebraska sandhill planting. It happens that western yellow pine seed from the Black Hills of South Dakota has succeeded reasonably well in both localities, but there is ample reason to believe that separate supplies of seed can be obtained for both localities which will prove even more fully adapted and which, in consequence will produce more rapid

growth and better timber. Speaking generally, however, there has been sufficient experience with plains planting in North Dakota to indicate the species which are hardy under those temperature conditions.

The difference in soils between North Dakota and the plains farther south is one whose effect on tree-planting the greatest expert would not dare to prognosticate, without the evidence supplied by tree growth itself. On the whole, however, the planting which has been done to date, some of it extending back 30 years or more, does not indicate anything more inimical to tree growth in the northern region than has been encountered further south. In both regions, where the rainfall is least, there is considerable tendency toward the formation of hardpans not far below the surface, which seem to put a definite limit on the life of forest plantations, even though they may not prevent the early establishment of the trees. Such hardpan formations in North Dakota are reported to be rather spotty in their occurrence, and the matter of breaking them up by blasting before planting trees on them, is one which should be given much more careful study than it has yet received.

With regard to the fertility of the sandhill soils of North Dakota, there can be no doubt that they possess sufficient "substance" for the growing of conifers, which on the whole demand very little of the soil. Certainly no sand, except possibly the coarse washed sand of an ocean beach, can be more purely silica than that of the Nebraska sandhills, yet even

that sand seems to possess all that the pines require. The question is rather whether the sand of McHenry County, which is much finer and more varied in composition, may by reason of this composition or as a result of poor drainage contain alkaline or other substances which may prove inimical to the rather sensitive pines. This question is one that must remain unanswered until tests have been made over a number of years, for the evidence is not at present at hand. It is for this reason that any plan of extensive planting in North Dakota sandhills should be preceded by tests on a small scale begun at the earliest possible moment. This matter will be gone into further in the discussion of the sandhill situation.

Farm Windbreak Planting

In a flat or gently rolling region without natural forests farm windbreak planting is of the utmost importance for protection, and perhaps equally important for its aesthetic value in relieving the monotony of the landscape. Experience everywhere has shown, however, that it can never be an important factor in timber production, for two fairly obvious reasons. The average farmer can not afford, or at least feels that he can not afford to give up any appreciable area of tillable land to timber production, the initial expense of establishing a forest being an additional barrier; the maximum of protective benefit from the planting of trees is rightly considered to be obtained when they are planted in rows or relatively narrow belts, and such planting is not conducive to the development of the best growing conditions for trees nor to the production of anything more than the rougher materials required for fence-posts or fuel.

Even in the central region of natural forest growth, where timber may be had without the expense of planting, somewhat the same psychology determines the extent and value of private timber on farms. There would be little of it if the farms did not contain some land too steep or too rocky for the usual forms of cultivation, and even such areas are commonly used for pasture and do not reach the optimum for timber growth. It is, therefore, hardly to be expected that the prairie farmer, having many obstacles to overcome before trees can be established at all, will go much further than his

urgent needs for protection dictate.

Even when the plains farmer has been induced, or through some temporary spur to his aesthetic sense, has planted trees of his own volition, he all too often stops cultivating them within a year or two, or before they have grown sufficiently to shade-out and choke out the sod, with the result that the trees never amount to anything, and it is fortunate if any of them are living after a period of 10 or 15 years. The farmer usually becomes convinced that trees "will not grow" in the plains, and it is to some extent true that individual trees or very scattered ones can not long hold their own against forms of vegetation which require only a seasonal supply of moisture. Besides this general condition there is in some localities a still greater menace to tree growth in the presence in the soil, at no great distance from the surface, of a hardpan layer. Unless this can be so broken (by blasting) before trees are planted, that their roots are permitted to go deep into the ground for reserves of moisture in drought periods, forest plantations can not be expected to live more than a few years. While some attention has been paid to this condition, the writer is not convinced that the possibilities of blasting hardpan have been given fair and ample trial.

It is noteworthy that except in southeastern North Dakota, which is, generally speaking, longer settled and richer than the rest of the State, there is practically no protection of fields by tree windbreaks. Practically all recent planting has been done for the protection of farmsteads only, and the two agencies hereinafter mentioned have about ceased in the

attempt to persuade farmers to do anything more.

In Zon's report, referred to at the beginning of this paper, evidence obtained in Russia is cited to show that windbreak planting in a plains region may have important climatic effects. Even admitting that the influence of forest planting is only for a short distance sufficiently pronounced to be susceptible of actual measurement and acceptable scientific proof, the writer is nevertheless convinced that a large number of extensive windbreaks and forest plantings must have an aggregate and general effect which is decidedly beneficial. Their province is to break up and prevent general drying winds, which, insofar as they originate through convectional currents set up on the plains themselves, must be modified and retarded by every variation in the terrain. Such variation may be produced in some degree by a wheat or alfalfa field standing in contrast to native prairie sod, it being easily proven that the air is cooler over the crop or area which gives off the greater quantity of vapor. Forested areas not only cool the hot summer winds passing over them but tend to divert, mix and retard horizontal air currents. The writer is convinced, even in the lack of definite scientific proof to be found in the weather records of the United States, that such amelioration of winds has occurred with the advance of cultivation and tree planting everywhere in the plains regions of the central United States.

If it be granted that numerous windbreaks may not only produce visible local effects upon crops but have a general effect in reducing winds, evaporation and soil-blowing, the

question then is, by what agency or means may more general tree-planting on agricultural lands be brought about? Although an occasional farmer may be "converted" to tree planting, for selfish reasons, through the steady hammering of agricultural extension workers and the present forestry agencies in North DaKota, few, if any, will undertake the expense for altruistic purposes or through the hope of sharing in a general and widespread benefit. If the thing is worth doing and is to be done, then, it will probably have to be done by the State or Federal Government.

It has been suggested by some of the most radical believers in the benefits of tree-planting in the plains, that the States or Federal Government should undertake to establish wide belts or strips of timber across the larger stretches of plains, at regular intervals, and each of sufficient width so that, once the trees were established after a period of adequate cultivation, they might be expected to create forest conditions, to continue growing, and to maintain themselves with a minimum of care. Even though it were impossible to place such belts close enough together (say every mile) so that all of the intervening land would be appreciably affected, such a plan, presenting the possibility of developing real forest conditions on an extensive scale, would have great advantages as a public undertaking. While such a development seems more or less chimerical and remote at the present time, we may develop some possibilities of the idea just a little further.

The State, in the public land states, owns a strip of land one chain wide on every section line, and in North Dakota, except in the poorer spots used only for grazing, nearly every section line has some kind of a road upon it. Of course, the greater number of such roads are not maintained by the State and receive only infrequent attention at the hands of the County road departments. It is an open question whether, in nearly every case, any individual farmer and the community as a whole would not have better road facilities if a much smaller number of roads are kept open, say every alternate mile in either direction. It is obvious that no attempt should be made to grow trees on the section lines which are needed for roads, since the two purposes are mutually inimical. Even single rows of trees beside roads often add greatly to the difficulty of keeping them clear of snow and of maintaining their surfaces in wet weather.

If, then, there are 16 acres of every section belonging to the State, we may assume that in a great number, perhaps a large majority of individual instances, 8 acres could well be devoted to the growing of timber belts rather than to roads. It will be assumed, merely for the sake of a simple picture, that these belts are all to run in one direction, say north and south, at intervals of two miles. Then the state-owned land taken out of road use would be equivalent to a strip 8 rods wide in one direction, the road land abandoned in the other direction being used for exchange with the farmer whose land was encroached upon, or for a series of exchanges which would accomplish the same result.

While the development of such a plan would involve a great number of trifling problems of land ownership and exchange, it would permit the State to undertake tree planting on an effective scale and basis without the purchase of land, and yet with the effort so distributed that all would benefit therefrom. The use of State school land for actual forest planting, or better still for compensating such landowners as could not be fairly compensated by the other form of exchange in building up the 8-rod strips, is worth considering. It is, of course, hardly to be expected that the strip plan could be carried out on every alternate north-south section line without variation, but it is unnecessary to go into such details here.

A similar project to be developed by the Federal Government, or by the State and Government cooperatively, does not seem impossible, although undoubtedly requiring special Federal legislation and possibly a state constitutional amendment which would probably be necessary in any event.

Existing Farm-planting Agencies

Nothing that has been said above is intended to detract from the praise which is due to two agencies already operating toward the extension of farm planting in North Dakota, and fulfilling that purpose in a businesslike and commendable manner. These agencies are the North Dakota School of Forestry at Bottineau, where a nursery is operated under the direction of the State Forester with the aid of a State Extension Forester, and the Bureau of Plant Industry, U. S. Department of Agriculture, through its Northern Great Plains Field Station

at Mandan, one of the primary branches of whose work is forestry. The latter extends its activities into South Dakota, Wyoming and Montana. These two agencies have gone far toward solving the pioneer problems of plains planting, having tested most of the promising species under various conditions, as also different spacings, mixtures and methods or degrees of cultivation. Their inevitable conclusion has been that it is wasteful, and only leads to discouragement, to supply trees to farmers except where an actual interest is shown, where the land has been cultivated at least a year before tree-planting, and where continued cultivation of the trees for several years after planting is assured. Practically all of the trees supplied (free or at cost) by these agencies are planted in compact blocks, averaging about 1 acre each, for the protection of farmsteads. One of the greatest difficulties encountered in a region devoted to wheat growing by the uses of cumbersome power machinery, is to obtain intensive cultivation after planting such as can be given by small cultivators working in both directions. The existence on farms only of wide cultivators requires spacing the rows at least 10 and preferably 12 feet apart, whereas the results of experiments both at Mandan, and in Saskatchewan across the border, point quite clearly to the desirability of closer spacing at the outset for the purpose of quickly protecting the soil and eliminating the competition of grasses and weeds. Also, if something in the nature of a thicket can be developed within a few years, the wind is more completely excluded, leaves are retained upon the ground, and moisture conditions are in every sense improved.

Both of the above agencies maintain their own nurseries, and heretofore have given much greater space to hardwood or broadleaved trees than to conifers, presumably because only broadleaves are native along streams and in the moister spots of the plains region and were originally thought to be "hardier" than the trees which carry their foliage the year around. The hardwoods are, at least, more easily planted by inexperienced hands. However, with sufficient evidence now to show that western yellow pine and Black Hills spruce from the west, and white spruce from the eastern or northern forests, as well as possibly a few others, prosper quite well under plains conditions, and having in view the greater ornamental value of the evergreens, they are gradually entering more and more into the nursery production and general distribution. The success of some of these species at Mandan under careful cultivation and at Dickinson under less favorable conditions are illustrated in Figures 3 to 7.

The following tabulation shows the extent of the effort that has been made by these two public agencies to date, as well as the current demands being made upon them:

	Bottineau (in North Dakota only)	Mandan (in Four States)
Number plantations established Total to date	1000	3300
Annual current	200	240
Current nursery output annual, thousands of trees	170-200	400
Percentage of conifers distributed	15	4-5

When one looks at a map of North Dakota and the adjacent areas of other states in which this work has been going forward for the past 15 years or more, one obtains the impression that a great deal has been accomplished in the establishment of demonstration plantations under a great diversity of conditions, so that from the standpoint of a solution of the technical problems little more could be asked. Of course, the acreage covered is insignificant in proportion to the vast expanse of the country, and the total effect from the standpoint of ameliorating the physical conditions would be too small to be measured. This is not an argument, however, for any attempt artificially to speed up the process through private effort, for as has been indicated above any plantation made without true interest and the willingness to give it care, and without the supervision and followup which is given to every one of these hundreds of undertakings annually, is more likely to lead to failure than success, and in forwarding this enterprise one real success is worth more than a dozen doubtful ones.

It is obvious, however, that the technical skill, and the energy and attention to detail necessary to plant a few hundred acres widely scattered over even one state, if applied to a well-conceived forestry enterprise of limited scope at any one time, could accomplish the planting of a much greater acreage. This is not in any sense an argument for the discontinuance of what is being done through the private planter, who obviously utilizes his small acreage for the maximum benefit to man and animals, but it does suggest that to bring

about any general benefit to the region and its people a large-scale public enterprise may be necessary.

No information is obtainable on the strictly private planting of stock purchased from commercial nurseries, which may have resulted from the semi-public demonstration plantings mentioned above. It is not greatly in evidence and certainly there has been no general or spontaneous turning to tree planting in recent years. And yet, unless the conditions in North Dakota are different from those elsewhere, it is practically inevitable that private planting, private nursery sale of trees, should have been stimulated to some extent.

To summarize these few paragraphs, it may be said that publicly-supported agencies in North Dakota are already doing about all that could be expected toward working out the problems and eliminating the pitfalls of tree planting on the average farms of the treeless plains, and in educating the entire citizenry through successful demonstrations. Yet, tree planting on an extensive scale, even to the extent desirable for purely protective purposes, is not being done, and is not likely to be done by the average farmer unless a real economic revolution affecting his attitude toward wheat acreage should cause him to look upon forested areas as something less than a total loss. That the individual farmer hesitates in reducing his own acreage of a given crop, without any assurance that his neighbors will do the same, is a well established fact and only what might be expected in any human society under the competitive system. It therefore follows that the most certain method of obtaining a decrease in wheat acreage and at the

same time of assuring the extensive planting of forests, which we believe would be of economic benefit to the state quite apart from the question of crop acreage, is for the State as a unit to set aside the area for such tree planting, well and equally distributed under some such scheme as has been outlined above, and as a public enterprise to plant and tend the trees as rapidly as the magnitude of the entire undertaking would permit. This is not a fantastic and visionary scheme promising either immediate relief or a solution of all of the ills suffered by agriculture, but does offer what may be termed a communal fulfillment of the need for forest growth primarily, and for possible timber supplies secondarily. Individual effort has never gone far toward filling such requirements.

Forests for the Sandhills of McHenry County

While North Dakota is fortunate in having an unusual area of tillable soil there are, besides the Badlands in the western part of the state, small areas of sandhills in two localities which are distinctly "marginal" as regards even grazing values and in large part sub-marginal for cultivation. The first and more important of these areas, from the standpoint of forestry, is very largely centered in McHenry County, barely extending beyond its boundaries at one or two points.

These sandhills are nothing like so high or rough, so continuous or so poor in soil values as the sandhills of Nebraska which have been mentioned in the discussion of the relative forest possibilities of North Dakota. There are here and there small areas of true sand-dunes, 30-40 feet high or more, some of which are decidedly active and practically bare of vegetation at the present time. For the most part, however, the sandy areas are characterized by small, choppy hills only a few feet in elevation, interspersed with areas sufficiently flat for cultivation, although generally more valuable as haylands since the soil blows too readily when once the sod has been broken. While, because of the occurrence of a good deal of aspen and brush cover, the grazing value of the rough areas is not of the highest, nevertheless any plan for forestry in these hills must take into account a legitimate grazing industry favored by the extent of the hay meadows, and a small amount of legitimate agriculture. It would probably

be difficult to find more than a few sections in any group which did not have any of these values. On the whole, it is inconceivable to the writer that extensive units which might be organized for forestry could be expected to develop much more than 50 per cent true forest land, but the interspersing of agricultural interests should be a help rather than a hindrance to the administration of such lands, since the value of the hay crop makes the settlers strongly in favor of fire suppression.

The Character of the Sandy Soils

The basis for the three separate units is the presence of sand-dunes, surrounded, as will be seen by reference to the Soil Survey Map for McHenry County, by considerable areas of either Valentine sand or Valentine fine sand. There is no sharp distinction between these two types except the fineness of the sand involved, and the occasional occurrence in the finer material of traces of lime. Both sand types are underlaid by sand of slightly lighter color which, according to the Soil Survey, "Continues to indefinite depths". The fine sand is stated to be somewhat more subject to blowing, and in general to give the more choppy topography; the coarser sand is stated to be a little more droughty, but there is little if any difference between their values for agriculture or for pasturage. Both are free of stones. In summary the Soil Survey states "The soils of the county are developed on glacial drift, glacial-lake deposits, river terraces, and flood plains. In all 10 series, embracing 31 types and 4 type phases, exclusive of peat, muck and dunesand, are mapped.

"The soils of the Valentine series are wind formed and easily drifted. They have a billowy to hummocky topography. The water table is high. The types mapped, the sand and the fine sand have a low value and are used principally for grazing.

"Dune sand is composed of loose, incoherent sand, subject to drifting by the wind. It affords very little grazing and is almost valueless for agriculture."

From the standpoint of forestry it is not so important that the areas mapped as suitable for tree-planting, and all of the areas covered by the Valentine sands, are within the area of the glacial Lake Souris, whose bed was superimposed on the drift-plain, as to note that both this lake-bed sand and most of the other soil types of the County are ultimately derived from glacial materials, and hence are of mixed character. The sands are, in this respect much more similar to the sands of the upper Great Lakes region than to the materials from which the Nebraska sand dunes have been formed. The former are in some instances quite fertile for the growth of pines, and are most sterile where heavily charged with iron as in some portions of the Upper Peninsula of Michigan. The brown to yellowish brown color of the sand of McHenry County does not indicate a greater quantity of iron than is desirable for the growth of coniferous trees, while the presence of a variety of other materials, including lime, derived from rocks of considerable variety, in general speaks well for fertility. As has been stated, however, only actual trial can show what the response of a given tree species may be to these soil conditions, and

one species may find them ideal while another will barely tolerate them. This variable response to minerals is much more likely to occur in soils of very low humus content than in good loams.

In the Nebraska sandhill planting the apparent lack of "substance" and fertility in the soil, which is about as pure a silica as can be found anywhere, has not proven a barrier to the rapid and vigorous growth of western yellow pine, and in fact all of the pines which naturally occur on rather light soils (specifically jack and Scotch, and to a less extent Austrian) seem to find abundant nourishment in this poorest of "poor sands". In the case of western yellow pine, which is a deep-rooting species, the lack of moisture-holding capacity of the light sand is also counterbalanced by the depth of the storage reservoir and the ease with which roots may penetrate to great depths in it. The other pines which do not commonly root so deeply have suffered much more evidently during drought years.

In attempting to state the case for the North Dakota sandhills, the writer feels a greater doubt regarding this soil factor than with reference to any other condition which may have to be met. There is absolutely no evidence on which to base even an inference as to whether the entirely different types of sand, of glacial origin, found in North Dakota, will prov friendly or inimical from the chemical side to the group of pine trees which could best make use of its physical characteristics. The writer has neither seen nor heard of any

pines planted on these sandhills, and it is for this reason that it is of the utmost importance that tests, on however small a scale, should be initiated at once since the effect of an unfriendly soil is frequently not observable for a number of years.

Some indirect evidence may be had, however, which points in opposite directions. Western yellow pine planted within the glaciated portion of North Dakota, at Mandan and Bottineau, on loamy to somewhat sandy soil presumably having somewhat the same chemical composition as the sand-hill sands under discussion, shows no evidence of an unfavorable soil condition, although jack pine does. Scotch pine in a gravelly glacial loam in southern Wells County has done suprisingly well, other circumstances considered, as it has also at the two points named above. On the other hand, the fact that Norway pine has never crossed the Red River valley, while several of the broad-leaved species of Minnesota have done so and occur both in the Turtle Mountains and in the sandhill areas, is strongly suggestive of a soil barrier affecting the pines.

The natural migration of western yellow pine in from the west would have been attended with much greater difficulties, especially as there is the wide non-glaciated strip of western North Dakota for it to cross. Its failure, therefore, should not be taken too seriously, considering its success as a planted tree. On the whole one must conclude that western yellow pine is likely to be the pine best adapted to the lightest soils of North Dakota, while the fact that they are composed of mixed glacial materials not lacking in a variety

of mineral elements gives strong hopes for the spruces and perhaps some other conifers of greater fastidiousness as to soil.

As stated in the Soil Survey report for McHenry County, the cover, so far as tree growth is concerned, consists of rather scattered groups of aspen (and another poplar not identified) elm, and burr oak on the sand dunes and the strictly sandy, billowy areass. Small hackberries were also noted in several places. In addition there are considerable areas covered with willows, buck-brush, silver-berry, June-berry and choke-cherry. Within the sand areas there are many areas of the better soil types on which aspen stands are more continuous and of good development, (Fig. 10) so that it can not be said that the region is by any means devoid of important timber growth. In fact, as illustrated in Figures 11 and 12 of this report, it is quite surprising to find old elms, hackberry and oak on the sand-dunes proper which have reached fairly good size in somewhat protected coves where there is opportunity for snow to drift in. From the information given in the soil survey, however, it is judged to be possible that in some instances the sandy surface soil of these dunes is underlaid by heavier material, which might account for such growth.

In township 158-75, toward the northern edge of the sand-hill area, bearberry (Arctostaphylos) and false indigo (Amorpha) were noted, these being common associates of western yellow pine in South Dakota and even in the sandhills of Nebraska.

Despite these evidences of forest potentialities furnished

by the native vegetation, the evidence is clear that the soils of the sand-dunes and of the Valentine sands are too light for the development of any hardwood species known at present, and it is not at sll likely that any hardwood brought in from the outside, even though adapted to such light soils, would prove to be as well adapted to the climate as the native species. On the other hand, barring some inimical chemical factor which can not be foreseen, there id every reason to believe that such sands as those of McHenry County will produce a coniferous forest of commercial value. While it is hardly to be expected that a forest of the very best quality can be grown with 16 inches of precipitation annually, (when one considers that 30 inches are required in northern Minnesota to produce high-quality timber on sand), nevertheless it is probable that saw-logs can be grown. The fact that the water-table in the sand areas is frequently within 8 feet of the surface, and hence within the reach of a deep-rooting species, suggest the possibility in parts of the area of augmenting the local rainfall by water brought from distant regions by the Souris River. At least there is available a deep storage supply which will tend to equalize growth from year to year despite variations in rain-fall, and is likely to preclude the wholesale loss of trees in drought periods once they are thoroughly established and deeply rooted. Because this storage supply does represent a portion of the effective rainfall which percolates through the sandy surface soil too rapidly to be most effective for tree growth, great care should be taken to select only deep-rooting species which can eventually utilize the most of the pre-

cipitation. The shallow-rooted spruces, if employed at all, should probably be placed only in the depressions, both because of the nearness of the water table and because they have need of the better soils of the depressions.

Plan for Planting the Sandhills

No reason is seen why the method of planting the sandhills in North Dakota should not closely follow the procedure which has proven effective in Nebraska under very similar physical conditions. Furrows are plowed at intervals of 6 to 8 feet and the trees planted somewhat more closely in them, six feet being the closest space in which furrows can be effectively run. This amount of plowing gives little opportunity for blowing of the sand, yet gives the trees a fair start ahead of the sod in immediate proximity to each. To some extent the actual planting operation is aided by machinery, and in view of the comparative ease of slopes on most of the North Dakota land, there is considerably more possibility of using planting machines, which are now being worked out elsewhere. However, until the technique with regard to size, age and species of trees most suitable to the situation has been worked out, the planting should all be considered experimental and cheapness should be made a secondary consideration. The present average cost of planting on a large scale in Nebraska is just about 1¢ per tree and it can not be expected this will be equalled for some time.

The patches of aspen and brush in the Dakota sandhills will prove more of an obstacle than exists in Nebraska. The

brush can, for the most part, be plowed through, however, and tree growth which is at all promising need not and should not be disturbed. It will be best to encourage in every way the natural growth which can have any value (as the local aspen certainly does have for fuel and poles) and to develop, for the sake of protection and soil fertility, a mixed forest rather than one purely of conifers.

The main problem is that of establishing and maintaining a nursery for the production of trees on a sufficiently large scale. It is believed that a nursery site near the planting ground should not be sought immediately, provided the State nursery at Bottineau, which is only about 35 miles distant from Towner, can supply stock on a gradually increasing scale during the first few years of the experiment, and provided it is shown that the development of the stock in the comparatively heavy soil of that nursery is suitable for its later planting in the very light sand. Heretofore the Bottineau nursery has not gone heavily into the production of conifers, yet the small numbers on hand at present show surprisingly good development, all things considered. Conifer production on a larger scale will almost certainly mean the sanding of a portion of the nursery soil, if not to direct root development, at least to make the soil easier to work and to insure that the tree roots are not badly broken in lifting. Should the Dakota sandhills prove to require transplant stock, such treatment would affect a large nursery area and be expensive.

The State nursery at Bottineau has now been authorized to make a charge for trees shipped to the citizens of the State, having heretofore supplied them gratis. It is not known whether this is to be a nominal charge or one representing cost of production, although it will certainly not exceed the latter figure. It is assumed that under a cooperative agreement, and having the benefit to the State through the Federal activity in mind, the Forest Service may at least receive the same consideration as a private planter, if it is decided to depend upon the State nursery for the stock needed. State Forester Cobb has been very much interested in this extension of Dakota forestry and we feel certain will do everything in his power to forward it.

Plan for Creation of a National Forest

Three possible forest units have been platted on the accompanying map, with a total acreage of 437 square miles, of which 21 sections lie just outside of McHenry County. The 416 sections within the county comprise 22 per cent of its total area of 1872 square miles, and if we assume that only half of this area will prove to be true forest land, 11 per cent of the county area will be involved. The total area of about 140,000 acres inside and outside the county may prove to be more than desired; however, the drawing-in of the outer limits at present indicated can best be done after a careful comparative study in the field.

Of the three possible forest units mentioned above, the one lies within the loop of the Souris River, is probably fairly well centered in the old Lake Souris bed and has the

greater portion of Valentine fine sand. The other two, north and south of Towner, respectively, on the east or outside of the River Loop, are essentially alike and were probably closer to the margin of the Lake, being separated only by a narrow strip of better soils of the Barnes series, directly east of Towner. In these two groups the coarse form of the Valentine sand prevails although there is nearly a township of the fine sand southeast of Towner (155-75). Such details as this can be learned from the complete soil maps attached to this report.

Although the Soil Survey report for McHenry County, written in 1921, states that lands of the Valentine sand and fine sand types are valued at from $3 to $10 per acre, the sale price of such land has depreciated greatly since the after-war boom. There has been a good deal of abandonment of the sandiest lands which have generally reverted to the County in tax sales at a price of one dollar per acre, and are so listed on the County books. Private transactions are known to have been made at a price of $0.50 per acre. Rentals received for State School lands vary, of course, with the use for which they are fitted, but rentals on the very sandy lands, when capitalized at 5 per cent or 6 per cent, indicate about the same scale of values or around a dollar an acre. It is therefore evident that, barring speculative holding, in the present condition of agriculture, it should be possible to obtain private land at this nominal figure. It has been stated that there is a good deal of absentee ownership of land in this County, and this will not facilitate its purchase,

as absentee owners are likely to have a very vague idea of true land values when depreciation has gone as far as it has here.

McHenry County owns through tax sales some 178 forties, of which 132 or about 5280 acres lie within the tentative forest-unit boundaries which have been outlined on the attached map. Of these a very few have been given valuations up to $1000 per quarter and would not be logically considered for forest purchase as they doubtless possess considerable agricultural value.

The State of North Dakota owns a number of school sections and also considerable other land in this locality. While some school sections have been disposed of the total State land in McHenry County is 50,455 acres, and within the tentative Forest Unit boundary 17,062 acres, or more than 1/18 of the entire area. Possibly 10,000 acres of this State land may be more suitable for forestry than any other purpose, and with the present very favorable sentiment in the State toward Federal forestry activity it is believed the land would be deeded to the government at a nominal figure.

Within the tentative boundaries there are 83 forties of government land, of which about 20 are covered by Homestead Entries. This remaining government land, with the exception of a few acres on the borders of alkali lakes, is naturally, the poorest in the County and would logically all be utilized for forest planting. There are only 16 additional forties of government-owned land in McHenry County, which serves to

show that sandiness has been the principal barrier to the settlement of all of the land in this region. It is very doubtful whether, except in the Bad lands, the government could scrape together in all of Dakota sufficient land to make an exchange with the State for its lands owned within the proposed Forest unit. Even there the amount which has not been deeded is relatively small, as is shown in the discussion of that region.

Sandhills of Richland and Ransom Counties

In eastern Ransom County and western Richland County, in the southeastern portion of North Dakota, the latter county being in part in the Red River valley, is a second area of sandhills almost if not quite as extensive as that of McHenry County. This sandy area is the result of delta deposits by the Sheyenne River near the edge of Glacial Lake Agassiz, the finer materials being carried farther out into the lake. Geologically and otherwise the sand is similar to the deposits in McHenry County, although not so deep, being underlain at a moderate depth by a clayey stratum which alters the drainage conditions. Also, so far as the writer was able to observe from a hasty and partial examination of the area, the sand is probably not quite so free of fine material in these southeastern counties, and hence does not blow quite as readily, with the result that the dune formations are much less general.

The Soil Survey for Ransom County states that there are 12,000 acres of dune-sand in that county, and the area in Richland County adjoining is of about the same extent. In addition there are in Ransom County 42,000 acres of Fargo sand and fine sand, while approximately 8 townships in the northwest quarter of Richland County are mainly the Fargo fine sand. Of the latter, however, the southern half is too generally swampy to be of any interest from the standpoint of forestry, so that we may place the area of well-drained Fargo fine sand

in this county at about 100,000 acres. This makes a total of 166,000 acres in the two counties which are sandy enough to have very low agricultural value.

It is quite possible that the forestry possibilities here are as great as in McHenry County, and the matter certainly deserves more exhaustive study. The writer, however, distinctly obtained the impression that the McHenry County area is much the more promising of the two and should receive first consideration. Factors which might mitigate against forestry in the Ransom-Richland area are (1) more general cultivation of the sandy soil types, possibly due not so much to intrinsic values as to proximity to the rich Red River valley and its markets. In this connection the increase from 16 inches of precipitation at Towner to more than 20 inches in the southeast corner of North Dakota is certainly an item in favor of the agricultural use of the poor soil types. (2) Somewhat more of clay mixed with the sand, a definite clay substratum (though very deep in some places) poorer drainage through the soil, and the possibility of noxious quantities of salts in the subterranean waters, would be decidedly unfavorable to the growth of conifers. These characteristics are witnessed by the more pronounced occurrence of the hardwood type in many places where the clay substratum evidently approaches the surface.

In brief, while the writer is not particularly an adherent of the "worst first" doctrine in the acquisition and reforestation of lands, the experience in Nebraska has indicated that with very light rainfall the clear sandy type of land is more favorable to the development of conifers than that of slightly

heavier type and heavier vegetation. It is believed, therefore, that serious consideration of a forest unit in Ransom or Richland County might well await a successful outcome of the McHenry County experiment.

A few views taken in northwestern Richland County, (Figures 19 to 22), will serve to illustrate the Fargo fine sand and dune-sand types.

A fair opportunity was presented to view the Badlands of Billings and McKenzie County, not at all in detail but still sufficiently to study representative physical conditions. The outstanding feature of these Badlands is the large amount of vegetative cover which they possess by contrast with the White River badlands of South Dakota. This again is obviously the result of greater moisture conservation in the more northerly territory, for certainly the soil in North Dakota is not more receptive to water.

The factor which keeps the soil of the Badlands essentially bare of vegetation is, of course, erosion, progressing at so rapid a rate that very steep slopes are maintained and vegetation is not given time to fix the soil. Where erosion is most active it is not merely a process of surface washing, but involves huge masses of soil which move bodily into the gullies cut by every rain of consequence. This mass movement presumably occurs principally in the spring after a long period for the accumulation of water, for the badland soils absorb only a small proportion of ordinary rains.

It is, then, from the standpoint of soil erosion, and that of controlling the movement of soil materials into the Missouri River, rather than from the standpoint of timber production, that any forestry proposal relating to the Badlands should be stated. This is not to say that the production of timber values is entirely out of the question, although it will

doubtless always be limited to such small items as red cedar posts, fuel, etc. The problem, then, is primarily one of soil stabilization so far as it can be accomplished by vegetation. The writer is convinced that it would require hundreds if not thousands of years to accomplish anything like complete stabilization of badlands soils by means of vegetation alone, and that any effort along this line must be supplemented by substantial engineering works. The primary reason for this is the depth of the valley of the Little Missouri, the steep slopes which separate the valley from the adjacent "table-land" on either side, and the fact that these slopes can never be stabilized through natural forces (such as the effect of vegetation) until the erosion has cut farther back and greatly reduced the gradients. Artificial means must be employed to counteract this difference in elevation, literally giving footing to the steep slopes by dams etc. which permit the water to fall in artificial, non-eroding channels. The principle of ponding the run-off water and causing settling of the eroded material is the same as that applied to gullies in agricultural regions.

Some of the badland ravines have already cut back to such an extent that the natural stabilization process has set in, as illustrated progressively in Figs. 30-32. This is the hopeful and encouraging feature of the entire situation, for it shows clearly that, once very steep slopes and the possibility of mass soil-movement are eliminated, the region is capable of

supporting sufficient vegetation to give a real protective covering. Under such a covering erosion becomes negligible, a condition which can not be attained either by engineering works alone or by the mere increase in vegetation.

Nothing that has been said above is intended to give the impression that efforts to increase the vegetative cover, and even to establish tree growth, might not be successful. The point is that this process could not go far enough to be even reasonably effective from the erosion standpoint, without in some way decreasing surface run-off and increasing moisture absorption by the soil, for the very small amount of moisture which gets into the soil on the steepest slopes will support practically no vegetation at all, or at the most an occasional bush which does not protect the soil and may in due time be cut away by the ever-deepening gullies.

The complete elimination of grazing from the Badlands, as might be possible under Government or State control of the lands, would be the necessary first step in erosion control. While it is undoubtedly true that the Badlands existed and were eroding rapidly long before cattle-grazing in this region started, this is not by any means to say that grazing has not made the situation much worse, the erosion much more active than formerly. There is probably no adequate proof of this except in the evidence from other localities, but the principle is incontrovertible.

The writer is strongly of the opinion that so far as forest planting is concerned and its possible effect on the

erosion of the steep slopes in the Badlands, more can be accomplished by working around the edges than by going upon the slopes themselves. In most cases the fan-like prongs of the rapidly eroding badland areas drain a considerable area of the uneroded table-land which, despite its gentle slopes and firm sod sheds rain water generously. This water from outside the eroding areas is probably as large a factor in the whole effect as the water which falls upon the eroding slopes. By putting more of it into the ground, as there is some hope of doing on the flatter areas, the possible rate of cutting would at least be greatly reduced. Furthermore, much of this water would doubtless seep to the surface within the eroding coves and assist in supporting a better cover there.

On an experimental basis, tree planting both in the rapidly eroding heads of several badland gullies, and also on the flatter portion of the amphitheater of each such gully, should be tried until the feasibility and possible effectiveness of each has been tested. On the flatter, sodded ground, the great hope for improvement of water-absorption which will make tree growth possible is the plowing of contour furrows. A succession of these furrows will catch the water which would otherwise fall over the precipitous slopes into the eroding areas; its absorption into the ground will give the sustenance for tree growth which does not exist under natural conditions.

Examination of the natural conditions shows that only a

slight increase in moisture is needed to make trees grow upon the sodded uplands. Thus, many small coves, and especially those facing the east which are the most likely to accumulate drifting snow, contain stands of green ash, and under the best conditions, aspen of a rather dwarf character. The quality of the green ash found in this region is really surprisingly good, showing that it needs only slight encouragement, such as would be given by the proposed contour furrows. It is obviously the tree which should first be given trial.

The first cover of raw slopes within the eroding Badlands proper is, apparently in nearly every case a perfectly flat, fine-needled juniper which may be called the "prostrate juniper" in keeping with its scientific name. This covers the ground in very much the same way as the evergreen bear-berry (Arctostaphylos) of sandy and gravelly arid regions, apparently layering, or forming roots on its long trailing stems to about the same degree. There soon appears after this juniper another which is either the common low juniper of widespread occurrence or its western counterpart. After further stabilization or under soil conditions which permit greater absorption of water into the soil appears the western form of red cedar, which forms rather open stands over quite extensive areas. There is no doubt that the natural growth of this tree juniper has been closely cut-out since the beginning of settlement, so that it is difficult to judge the stature eventually reached, but there is scarcely any doubt that it generally grows to fence-post size.

Under the most favorable conditions western yellow pine may be found in the Badlands, but it is doubtless of very limited distribution. The necessary moisture absorption for its growth occurs either in conjunction with a layer of sandstone which outcrops at different levels in different portions of the Badlands, or in conjunction with the presence of "scoria". Scoria is nothing more than the shale typical of the entire badlands area, baked, through the combustion of lignite seams, to the consistency of soft bricks, which it resembles also in color. Due to the baking, scoria layers, often many feet deep, do not "puddle" and become resistant to moisture absorption when wetted, but remain porous and absorbent like a covering of cinders. Therefore, scoria insures much better moisture absorption than the prevailing unbaked shale or blue gumbo.

So striking are these successive stages of vegetative development as to point clearly to the fact that it is not the limited amount of precipitation (fifteen inches per annum) which causes the western Badlands to be so barren and desolate, but the very rapid run-off. I venture the estimate that under the extreme conditions of some small watersheds two thirds of the precipitation finds its way immediately into streams, carrying with it an enormous load of fine silt. Probably for the badland areas as a whole an estimate of 50 per cent run-off would not be too high. In other words, out of the total, admittedly limited precipitation, only 5 to 8 inches get into the soil

at all. In Colorado, certain mountain valleys with this amount of precipitation produce only a semi-desert vegetative cover. Under such conditions, even a very slight increase in absorption means the turning-point between barrenness and at least a moderately complete vegetative cover. But, from the other side, the effect of the wasted run-off water upon streams, it is desirable to change the absorption-run-off ratio as fully as possible, since any run-off from such ground is bound to burden the headwaters of the Missouri with silt which is, because of its fineness, carried far down the stream.

It is impossible to conceive of an area whose conditions have an influence on the flood and silt problems of the Mississippi, and even more particularly upon the possibility of navigation in the lower Missouri, in which erosion control is more feasible or would pay higher returns on the investment. This is both because we are dealing with headwater conditions where the engineering problems are comparatively simple, and also because there is no important land-use to be interfered with. The flooding of the main valley of the Little Missouri would drown out a few ranch headquarters, some hayland, and timber. But practically any of the side valleys which feed the Little Missouri from the active eroding areas could be entered without disturbing anything but grazing values.

If experimental work with vegetation is entered upon in this region, it should be coordinated with an engineering attack,

also on an experimental scale. By this the writer has in mind the complete control, or attempt at control, of watersheds up to a section in extent. To the end that Government land may be available for such experimentation it is recommended that some portion of the 23,000 acres of Government land remaining in Billings County (about one township out of a total of 32) be withdrawn from entry and set aside for experimental purposes immediately. If this is not a blanket reservation, attempt should be made to find areas as accessible as possible to U.S. Highway 10 or 85.

No attempt will be made in this memorandum to go into details regarding a planting-erosion control experiment in the Badlands, beyond pointing out that before planting is undertaken, stock of green ash, western red cedar and possibly also western yellow pine, grown from seed collected in western North Dakota, should be made available. In anticipation of the need, suggestion for such seed collections by the North Dakota School of Forestry and State Nursery may be made, with the statement that even though such experiments should not materialize, the stock so grown would be extremely valuable for farm plantations made in the western part of the State.

Kildeer Mountain

In Dunn County, in western North Dakota, and practically on the eastern border of the deeply eroded Badlands, lies a prominent uplift (See Fig. 34), scarcely of sufficient extent to be of public interest from the standpoint of its forests, and principally of concern in this report as illustrating the principle brought out in the disoussion of the Badlands, that it is not the low precipitation of the region which definitely limits forest growth, so much as the inability of the soil to absorb the moisture which is supplied.

This uplift, known as Kildeer Mountain, covers about a township in the aggregate, but its comparatively flat top is only three or four square miles in extent. This flat top is defined by the limestone cap which is crumbling, of course, at the edges, strewing the slopes with enormous boulders. The cap, due to the impermeability of the soil derived from limestone, and also to the fact that a strongly limy soil is not tolerated by all forms of vegetation, and is more "droughty" than less alkaline soils, is practically devoid of tree growth, and in fact comprises a high meadow used for grazing purposes. On the other hand, the more broken slopes, at the levels at which less limy strata outcrop, are fairly well forested, aspen being here the most abundant species. There are here and there bare ridges on which the conditions appear too severe for tree growth, but every cove is solidly covered. It is barely possible that a small amount of water seeps into the soil on the top of the mountain, and is brought to the surface in these coves to add to the local supply,

but the amount of such absorption, in excess of the requirements of the sod which covers the mesa area, is certain to be very small. It is, therefore, evident that, even in this region, the only requirement to make timber growth possible is that the surface of the soil be sufficiently porous to permit reasonable absorption of the precipitation. This is, to our mind, an extremely encouraging fact, in considering what may be done in the Badlands with artificial aids to nature.

Forests of the Turtle and Pembina Mountains

The timber conditions in the two areas of high hills near the north boundary of North Dakota are probably much better known to the average resident of North Dakota and to the outsider, than the other conditions discussed in this report, because of the extent to which these uplifts, with their scattered farms and timber-patches, are visited by recreationists, hunters and those who seek the out-of-doors merely for "touring" purposes. Moreover, the report by Zon, previously referred to, has covered this region quite completely. The present report will confine itself to a few generalizations.

First of all, there can be no doubt that the Turtle Mountains (and it is understood that the Pembina Mountains are very similar though more limited in extent) comprise a natural forest area, or in other words, that the physical conditions are quite generally sufficiently favorable within them for timber species to take hold and grow without the aid of man. Apparently these areas were very largely covered with timber when the first settlers appeared, and are only kept from being so at the present time by cultivation of most of the flatter tracts within them. There is indeed good soil on these gently rolling hills, and farmers on them are said generally to have fared better than the prairie farmers. It is believed that it would be well worthy of study to determine whether the hills receive more precipitation

than the surrounding plains, and whether this is the primary reason for their forest-growing capacity.

The outstanding feature of the Turtle Mountains is the total lack of conifers in their forest stands, while many of the eastern hardwoods have migrated to them.

From the standpoint of forest productiveness, the existing situation is near enough to the ideal to preclude the need for public interference. There are only a few scattered forties of Government land either in the Turtle Mountains or Pembina Mountains. In short, the timber-land, as well as the tillable land, is largely in private ownership, and the two are worked together, the timber giving winter occupation to the land owners and a supply of fuel and poles to the nearby dwellers on prairie farms and in villages. Since the younger timber is largely aspen which springs up quickly from sprouts after a cutting, there is practically no question as to the perpetuation of the forest cover, and indeed it appears that abandoned fields go back to forest in a very few years. There is, however, a fair degree of stability in the relative areas of land tilled and in forest.

On the other hand, the value of a wooded, slightly elevated and cooler area, with springs, streams and lakes, for recreational purposes, is immense in such a state as North Dakota, and is such as to raise the question of public ownership or control for this purpose primarily. Both because of the wide travel which is possible for nearly everyone now, and

because the Devils Lake region, due to recession of the lake itself, has become less attractive in recent years, the Turtle Mountains are becoming increasingly popular at least to people from nearby portions of the State.

The region is certainly not distinctive enough to be classed in the same category as the National Parks. Therefore, it would seem to be a question to be decided wholly by the people of North Dakota whether the recreational advantages will be sufficiently conserved, and will remain sufficiently accessible to the general public, under private ownership of the land, or whether these very tangible assets are worth the price which would have to be paid to create and maintain a State Park or Forest, preferably the former, as it is felt the aesthetic values should be paramount. The general experience would lead one to suppose that while, with very limited recreational use, private ownership and the existence of a good deal of farming may not have been a disadvantage, as the demand increases there will be a growing tendency for land-owners to abandon farming and to begin placing a price upon the natural advantages, so that eventually it will be necessary for the State to take over the land and at a higher price than would now be reasonable.

It would not be necessary for the State to purchase the entire timber-covered area, nor to drive farmers out of business to any appreciable extent. The boundaries of a State Park might be made inclusive, but only the critical lake shores, spots of unusual attractiveness, and right-of-ways for an adequate system

of roads need be publicly owned in order to insure their preservation and accessibility. The fire-hazard is comparatively low in a forested region of this type, and existence of cultivated areas tends to keep it lower. The development of summer homes in abundance can go on as well under private ownership as by a leasing system.

River-Bottom and Lake Shore Timber

In the aggregate there is a very considerable area of forest and an important quantity of usable timber in North Dakota on river bottoms and near the shores of its many lakes. Of the former, the Missouri River bottom is most extensive and continuous, while of the lakes, Devils Lake, Pleasant Lake and Stump Lake are typical examples.

For the most part, the timber of the Missouri River bottom is cottonwood, although other species, such as basswood, occur more or less abundantly in limited areas. The prevalence of cottonwood is probably to be accounted for by the frequent shifting of the land areas subject to overflow and erosion by the river, together with the fact that land still subject to these influences may be under water for long enough periods to drown out any species other than those of the poplar-willow family. In short, the cottonwood and its close relatives are the natural first invaders of "new" alluvial land, while the more valuable basswood, elm, etc. are to be found on slightly less moist river bottoms where a greater degree of stability and permanence has been attained.

In the upper reaches of the Missouri River, or at least in the immediate vicinity of the Badlands, as at Williston, green ash is seen in extensive stands on the river bottom. As has been pointed out, green ash is one of the commonest species within the Badlands themselves, and its ability to occupy river-bottom lands is the result of the more droughty soil and rainfall conditions which are typical of the badland region.

As might be expected, the lake shore forests, which are generally in the eastern part of North Dakota, show much the same features as the more stable river-bottom forests, with the more frequent occurrence, however, of burr oak, which may be associated with well stabilized, and probably also drier conditions than the other species mentioned above. The surprising thing about the lake shore forests of North Dakota is not their general occurrence near water levels, but that even around such deep-set lakes as Stump Lake, the timber prospers as far away from water as the tops of the adjacent hills or plains level. While this may not be due entirely to moisture, but also to such factors as grass fires which are believed to have had much to do with limiting forest extension into the prairies everywhere, nevertheless there is a suggestion here that the slight addition to atmospheric humidity from the surface of a large lake may extend the critical area in which the moisture supply is adequate for the hardwoods.

Both the lake-shore and bottom-land forests of North Dakota are, naturally in view of their limited extents, included in farms. Agitation in the interest of their public control has arisen not so much from any feeling that their timber values must be conserved, as from what may be called an extraneous factor. This is the recession of lake levels, notably in the case of Devils Lake, which has created barren and unsightly mud-flats where once there was an attractive water surface.

It has been assumed that this land might be covered with tree growth and thus restored to some of its original usefulness as recreation grounds. It is our candid opinion that this is wholly out of the question because of the alkalinity of these flats, and that the best that can be done with them is to drain them sufficiently to convert them into reasonably good hay meadows, since there are plenty of alkali - tolerant grass species in the region. It is true that such tree species as willows can be made to grow under these conditions. More desirable species require better drainage than could be obtained here even by artificial means, and greater freedom from alkali than is likely to result in less than a century of leaching. That it would be desirable to attempt to restore beauty to the scene by planting willows the writer does not for one moment suggest, having never seen a willow thicket which possessed any aesthetic value.

Whether or not the recession of lake levels in this region is permanent or at least in part the result of a climatic cycle, remains to be seen, although the evidence is largely in favor of permanence. The fairly obvious explanation is that in a flat country, originally covered by a tight sod, cultivation of the surrounding territories has generally resulted in percolation of rain water where formerly, at least after sudden down-pours, there was a very heavy run-off. Only one fully familiar with the level prairies can realize how great the run-off is under certain conditions. Moreover, the water now getting into the soil of

cultivated fields does not become available as seepage, but is largely utilized by the growing crops. In short, North Dakota can not have both her wheat and her lakes.

The argument against public control or ownership of river-bottom forests, except locally as they may be required for park purposes, is their lack of compactness, they being for the most part belts of a mile or less in width. Considering also the unstable character of the land occupied generally by the cottonwood forests, which are doubtless of the greatest extent, and the fact that such river-bottom land is legitimately given to agriculture whenever and wherever it is sufficiently free from inundation, it is believed that a somewhat hand-to-mouth treatment of its timber-lands, such as it will receive under private ownership, is the only treatment which is economically justified.

The bottom forests of the Missouri originally furnished vast quantities of fuel-wood, one of the few uses to which cottonwood can be put. Fuel and occasionally more valuable products are still being cut from these same forests, which reproduce easily though somewhat spasmodically. Perhaps this utilization is not as systematic and effective as it might be. However, the market for fuel and other low grade forest products is none too reliable, especially in a region teeming with lignite mines, so that it is not evident that more could be made of this resource, of benefit to the region as a whole, even if it were carefully managed. Were we dealing with tree

species of greater intrinsic value, or with land not subject to inundation (and even to complete cutting away by the River), the attractiveness of a public forest which might supply some of North Dakota's definite needs for lumber would be far greater.

There is, it seems to the writer, one possible justification for public ownership and control of some of the river bottoms, including all of that of the Missouri in North Dakota. This would be in connection with navigation problems and with a definite project to control the amount of silt reaching the headwaters of the river, as suggested under the Badlands discussion. Given the maximum reasonable control of such tributaries as the Little Missouri, by means of engineering works which effect a considerable degree of water (and silt) storage in small reservoirs, there may still be exceptional periods when floods will occur on the main river, although they should be of less severity than before. Would it, then, be wise to maintain the flood plain or first bottom of the Missouri River in timber as largely as possible, for the purpose of forming a trap for such flood waters, through all of North and South Dakota, perhaps, or at least in various sections of these two States? Anyone who has ever visited a bottomland cottonwood grove after an inundation will be able to visualize what is meant. While a stand of trees can only impede and slightly detain the flood of water, its efficacy in ridding the stream of its solid load is enormous. Floating material is literally "screened out", and the coarser silt is quickly dropped in the slower-moving water. The deposition of

this material would tend inevitably to build up the land where the timber stood, ultimately raising its level enough to permit a better quality of growth. It would be unsafe ever to cut the timber from such a built-up area except in very narrow strips, for it would always be subject to the reverse process of cutting down, which would annul its previous benefit. However, it would seem that a system of "screen forests" could be established at intervals along the Missouri, without in a large measure curtailing the agricultural use of the bottom-land, and that such a forest system might be of inestimable value in protecting the lower River in times of exceptionally high floods, for the control of which every possible barrier to direct run-off must be raised.

Summary

Even in a State which to the casual traveler appears as flat and uniform as North Dakota, there is a great variety of physical conditions, each of which is clearly reflected in the amount and character of the forest growth. The present forests of greatest potential commercial value are those of the river bottoms and lake shores, and those of the mountainous uplifts on the northern border of the State. Such forests are quite widely distributed over the State, but are not of sufficient extent to have a great deal of influence on her climatic or living conditions, and are not so bunched as to lend themselves well to public management, especially in view of the fact that within each such type there is a considerable proportion of valuable agricultural land.

Forestry on an extensive scale must turn to low-grade lands not profitable for agriculture. Of these, the sandhills of McHenry County (and those of Ransom and Richland probably less definitely) offer the best opportunity for the development of that type of forest which North Dakota does not possess, a forest of conifers or softwoods which, it is earnestly believed by the writer of this report, may be expected to produce saw-log timber.

The Badlands region, because of its extremely low rainfall and heavy shale soils, can not be expected to produce much more than a scant forest cover although even the trees which will grow

there are not without their value in an agricultural State. Because of the extremely low value of the lands and their extremely great importance as contributors of silt and flood waters to the Missouri River, forest extension, combined with engineering works in the Badlands, should be looked upon primarily as a stream-control measure of the first order. If the project were approached in the generous and extravagant spirit in which the proposed diversion of the Missouri north of the Coteau de Missouri has been suggested, there is no limit to the benefit which might be felt on the lower Missouri and Mississippi. Besides, the writer believes that the ponding of water within the Badlands on an extensive scale might be felt as a climatic influence in the territory to the east.

Finally, there are very large possibilities in developing a plan by which more extensive forest planting in the plains region proper may be obtained, with almost unquestionable benefit to the crop-growing and living conditions in proximity thereto. Private initiative and altruism does not seem adequate to produce the necessary results, and the possibility of a systematic State undertaking should be given most thorough consideration.

All of these possibilities deserve, first of all, experimental trial by an agency working with a free hand and with the public benefit foremost in mind. A few years of experiment, not in an academic way, but with a view to the possible future magnitude of the undertakings, would do much to clarify their technical problems and indicate their costs and possibilities of success.